THE IMPACT OF SURFACE PROPERTIES AND DUNE FORMATION HYPOTHESIS ON PREDICTED DUNE TRANSPORT AND ORIENTATIONS IN THE AEOLIS RESEARCH TITAN GCMS.

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Introduction: Dunes dominate Titan's equatorial regions and likely reflect the magnitude and direction of winds over the current or past climate epochs [1]. Their morphology and interaction with small-scale topography suggests that net transport of dune material is westerly (i.e., from the west), in contrast with theory and modeling that predicts easterly winds should dominate at low latitudes [2]. One explanation is that material is only moved by wind stresses above a relatively high threshold, and that exceptionally strong westerlies sometimes occur that exceed this threshold, whereas peak easterlies largely do not. Dunes would then form primarily during the periods when such strong westerlies occur.

Possible mechanisms that have been proposed for producing strong westerlies include (i) seasonal variability, with strong westerlies occurring around both equinoxes [2], (ii) mesoscale circulations produced during methane storms generating regionally strong westerlies [3,4], and (iii) the effects of topography on wind speed/direction at different orbital epochs [5].

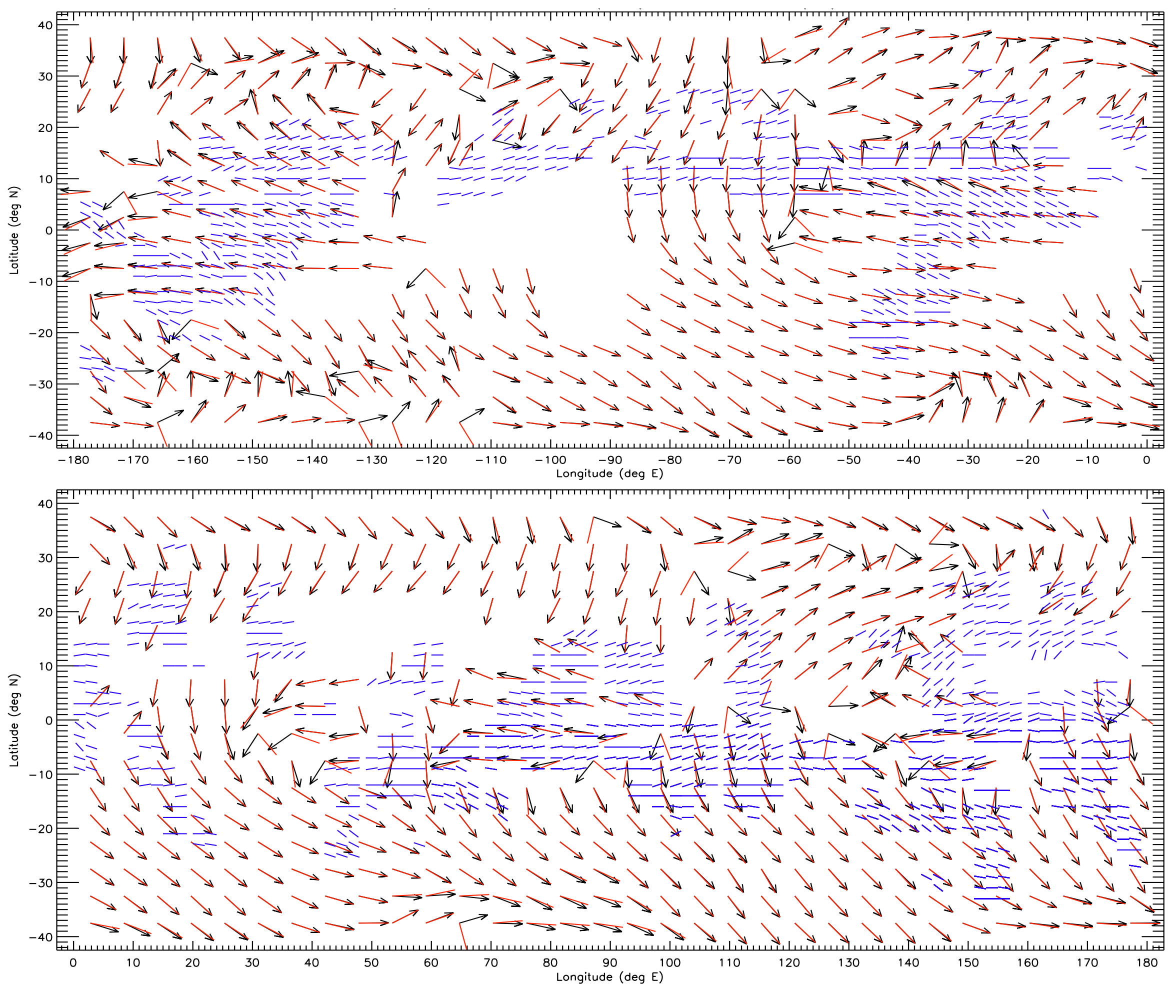

Figure 1: Top panel shows -180 to 0° E, bottom panel shows 0 to 180° E. Predicted net transport directions (black arrows) and dune orientations (red lines) assuming Fingering Mode hypothesis, based on TitanWRF surface wind stresses over 1 Titan year with a preliminary topography map included, assuming a threshold of 0.018 Pa and calculating fluxes as in [10]. Also shown (blue lines) are observed dune orientations from [11].

However, another constraint on the dune-forming winds is the orientation of dunes on the surface, and no study has yet demonstrated a good match to both the inferred direction of material transport and the observed dune orientation at all locations on Titan's surface. Current aeolian theory suggests that, in areas of unlimited sediment supply, dune orientations will be determined by the Gross Bedform-Normal Transport (GBNT) hypothesis of [6], whereas in areas of limited sediment supply they will be determined by the Fingering Mode hypothesis of [7].

[5] showed net transport and GBNT dune orientation predictions using three atmospheric models of Titan's near-surface circulation, including the TitanWRF General Circulation Model (GCM) [8,9]. We will present results from both Aeolis Research Titan GCMs (TitanWRF and the Titan MITgcm), and will additionally look at Fingering Mode predictions.

Figure 1 shows predicted dune orientations (red lines) and net transport directions (black arrows) in TitanWRF with topography, using the Fingering Mode hypothesis, while Figure 2 shows net transport direction only from the Titan MITgcm. Although both models predict easterly transport when run with a flat surface, the inclusion of topography appears to cause results to diverge, and far more low latitudes westerly net transport appears to be predicted in the MITgcm than in TitanWRF.

We will focus on the impact of including realistic surface properties and examine whether mismatches between observed and predicted dune orientations - as well as the model-to-model differences - may be due to smaller-scale topography and dynamic processes such as eddy activities.

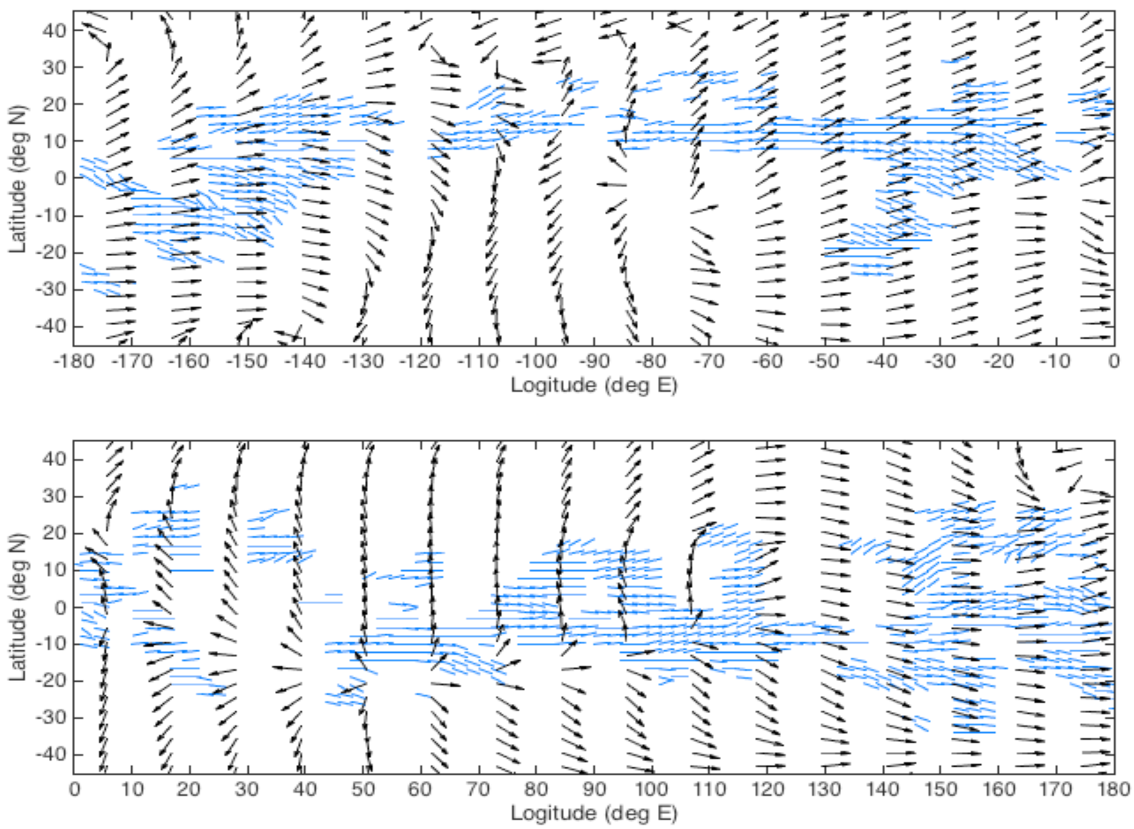

Figure 2: As Figure 1 but showing only net transport directions predicted by the Aeolis Titan MITgcm.

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